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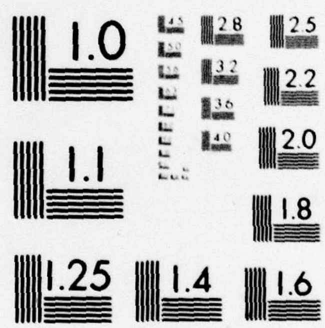

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FOREIGN TECHNOLOGY DIVISION

SGD $\frac{4}{4}$ RAD ANTENNA

By

V. D. Kuznetsov, V. K. Paramonov

EDITED TRANSLATION

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Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

SGD $\frac{4}{4}$ RAD ANTENNA

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A description is given of an antenna with a wide-band active reflector. Recommendations are given for the conversion of cophased tuned antennas into wide-band, and results are given from an experimental check of two antennas, converted from typical cophased antennas with a tuned reflector.

A cophased antenna with a wide-band active reflector, the SGD 4/4 RAD, just as the cophased antenna with a tuned reflector, the SGD 4/4 R, consists of two similar vibratory arrays which are separated from each other by one fourth of the center wavelength. Each array contains eight symmetric vibrators (two four-tier sections). The antenna is supplied with power with the help of a directional coupler (NO) with a specific power shunting coefficient. The layout for power supply is shown in Figure 1, where: 1 - transmission line from the transmitter, 2 - directional coupler, 3 - absorbing line, 4 - downlead feeder lines from the antenna array, 5 - downlead feeder lines from the reflector array. This layout for power supply is related to the most widespread and simple variant, when the antenna does not have either a reverse switch or a switch for controlling the radiation pattern. As is evident from the drawing, the downlead feeder lines from both sections of the antenna and the downlead feeder lines from both sections of the reflector make a parallel and connect up to the corresponding outputs of the NO. The transmission line from the transmitter and the absorbing line are connected up to the remaining ends of the NO.

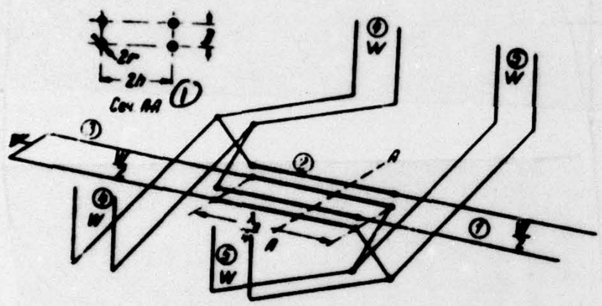


Figure 1.
Key: (1) Section A-A.

The directional coupler represents two spatially connected symmetrical double-wire lines. It is made out of four sections of tubing or a rod of equal diameter. The length of the NO is taken equal to $\lambda_0/4$, where

$$\lambda_0 = \frac{c}{f_0}; \quad f_0 = \frac{f_{\text{мин}} + f_{\text{макс}}}{2};$$

$$f_{\text{мин}} = \frac{c}{\lambda_{\text{макс}}}; \quad f_{\text{макс}} = \frac{c}{\lambda_{\text{мин}}};$$

$C=3 \cdot 10^8$ m/s; f - frequency, Hz; $\lambda_{\text{мин}}$ and $\lambda_{\text{макс}}$- shortest and longest wave of the operating band of frequencies, expressed in meters.

The diameter of the tubing of the directional coupler and the distance between them are selected so that on the wave λ_0 the power arriving from the transmitter would be divided between the arrays of the antenna and the reflector in the ratio of 4/5 to 1/5, and in this case the NO would agree from all sides with a resistance equal to half of the wave resistance of the downlead feeders.

In typical SGD 4/4 R antennas the downlead feeders have a wave resistance of 550 or 600 ohms, and in the conversion of such antennas to SGD 4/4 RAD antennas it is necessary to calculate the directional coupler for agreement from all sides correspondingly with a resistance of 275 or 300 ohms.

The dependences between the distances 2h, D and the diameter of the tubing 2r (Figure 1) for NO with the required shunting coefficient based on power $\left(\varphi^2 = \frac{1}{5} = 0.2\right)$, balanced from all sides with a resistance of 275 or 300 ohms, are depicted graphically in Figure 2.

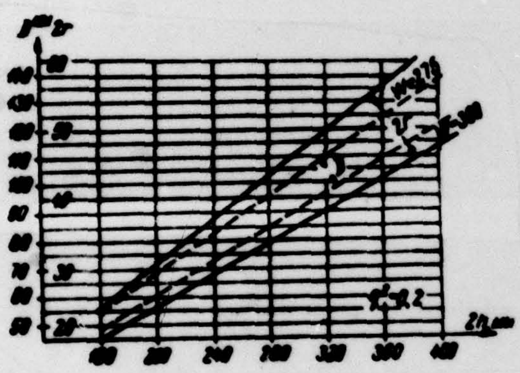


Figure 2.

These graphs can be used for determining the distance D and the diameter of the tubing 2r, if the distance 2h is assigned, or for determination of distance 2h and D based on assigned diameter of the tubing 2r.

The lines connecting the sections of the antenna and reflector arrays with the NO should have equal electrical lengths with an accuracy to $\pm 0.01\ \lambda_0$. The jumpers between the points of connection in parallel of the downlead feeders and the NO should also have a wave resistance of 275 or 300 ohms correspondingly and can be made in the form of segments of the feeder out of multiple-wire cylindrical "sausages."

The absorbing line with a wave resistance of 275 or 300 ohms can be made out of 2-millimeter Fechral wire in the form of an uncrossed six-wire feeder line, a cross section of which is shown in Figure 3. In this case the dependence between the distances D_1 and D_2 is expressed graphically, as is shown in this same Figure 3. It is necessary to connect conductors of the same sign between one another with jumpers which are located at a distance of an order of $\frac{\lambda_0}{8} \div \frac{\lambda_0}{6}$ from each other. The length of the absorbing line should be no less than 3 λ_0. The end of the line should be shorted and grounded.

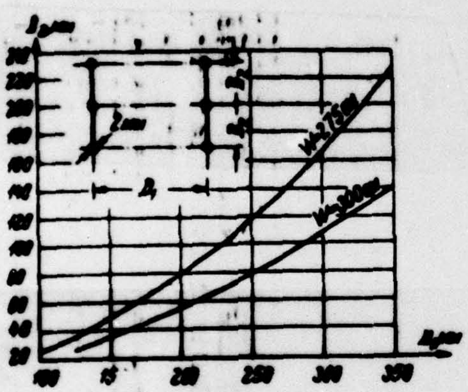


Figure 3.

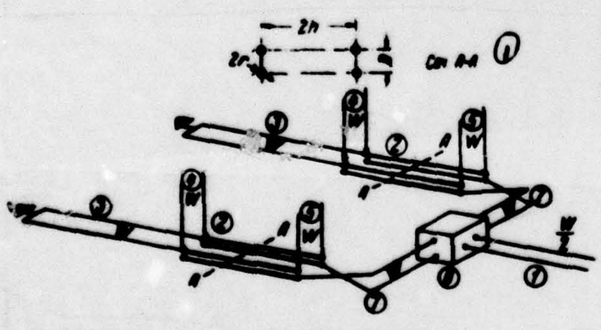


Figure 4.
Key: (1) Section A-A.

The layout for power supply of the SGD 4/4 RAD antenna with a switch for controlling the radiation pattern is shown in Figure 4, where: 1 - transmission line from the transmitter, 2 - NO, 3 - absorbing lines, 4 - downlead feeder lines from the antenna array, 5 - downlead feeder lines from the reflector array, 6 - switch for control of the radiation pattern, 7 - lines, connecting switch 6 with the NO. In this case the NO is included between the downleads of the antenna and the reflector in each of the two sections and is calculated for agreement from both sides with a resistance equal to the wave resistance of the downlead feeder lines, i.e., 550 or 600 ohms.

The dependences between the distances 2h, D and the diameter of the tubing 2r for NO with a shunting coefficient q^2=0.2 are characterized by the graph shown in Figure 5. As is evident from the graph, in this case the NO can be made out of standard or bimetallic wire with a diameter of 4-6 mm. The length of the NO is $\frac{\lambda_0}{4}$.

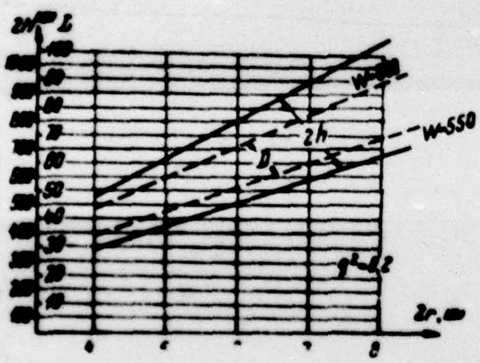


Figure 5.

The absorbing lines also have a wave resistance of 550 or 600 ohms and can be made in the form of a four-wire uncrossed feeder line made out of Fechral wire 2 mm in diameter. The cross section of such a feeder line and the graph of the dependence of distance D_2 on the distance D_1 are given in Figure 6. The analogous wires of the line are shorted by jumpers which are located at a distance

$\frac{\lambda_0}{8}+\frac{\lambda_0}{6}$ from each other. The ends of the absorbing lines are shorted and grounded. The length of each line is no less than 3 λ_0.

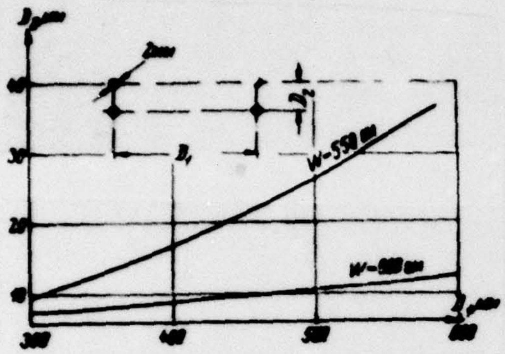


Figure 6.

The switch for control of the radiation pattern 6 is hooked up in such a way that the feeder lines 7, connecting it with the NO, would be equal to each other in length. The equality of the electrical lengths of lines 7, as well as that of the downlead feeder lines 4 and 5, should be maintained with an accuracy to $\pm 0.01\ \lambda_0$.

The layout for power supply for the SGD 4/4 RAD antenna with a reverse switch, but without a switch for control of the radiation pattern, is shown in Figure 7, where: 1 - transmission line from the transmitter, 2 - NO, 3 - absorbing line, 4, 5 - downlead feeder lines from the sections of both antenna arrays, 6 - reverse switch, 7, 8 - lines, connecting the NO with the reverse switch.

In this layout the reverse switch is hooked up between the NO from one side and the power supply feeder line and absorbing line from the other side. A second variant of the arrangement is possible, when the reverse switch is hooked up between the NO and the points of connection in parallel of the downlead feeder lines.

With equal conditions preference should be given to the first variant of the layout (Figure 7), since in this case the requirement for equality of the electrical lengths of the connecting feeder lines 7 and 8 drops out, while in the second variant its satisfaction is compulsory.

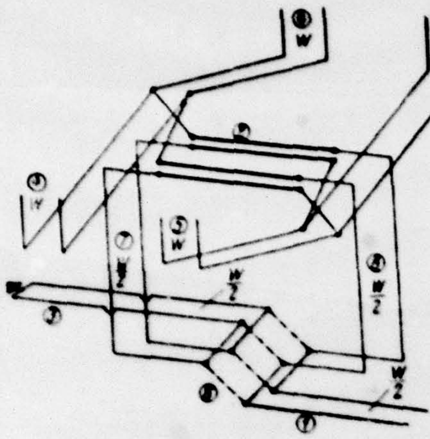


Figure 7.

The NO and the absorbing line for the layout shown in Figure 7 are calculated the same as for the layout in Figure 1, i.e., using the graphs depicted in Figures 2 and 3.

There is a more complex arrangement for power supply of the SGD 4/4 RAD antenna with a reverse switch and a switch for control of the radiation pattern. This layout is shown in Figure 8, where: 1 - transmission line from the transmitter, 2 - directional couplers, 3 - absorbing lines, 4, 5 - downlead feeder lines, 6 - reverse switch, 7 - switch for control of the radiation pattern, 8, 9, 10 - feeder lines, connecting the reverse switches with the NO and switch 7.

Here, just as in the previous case, a second variant of the power supply arrangement is possible. It is characterized by the fact that the reverse switches are not hooked up as is shown in Figure 8, but between the NO and the downlead feeders of the sections. Apparently in this case also preference should be given to the first variant.

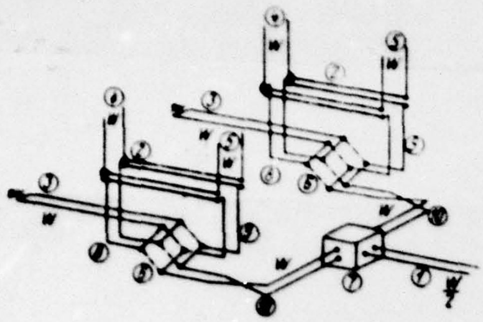
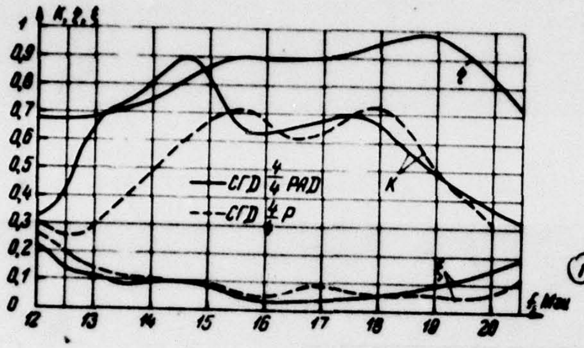


Figure 8.

The calculation of the NO and the absorbing lines for an antenna with the power supply arrangement depicted in Figure 8 is done using the graphs presented in Figures 5 and 6, which are related to the layout given in Figure 4.

The power supply arrangements given above for the SGD 4/4 RAD antenna, and also the recommendations for fulfillment of the main elements of the power supply layouts are given relative to the structural features and electrical parameters of the typical SGD 4/4 R cophased antennas with a tuned reflector in order to facilitate to the maximum the conversion of such antennas into wide-band.

Based on recommendations analogous to those given above, at one of the radio transmitting stations two typical SGD 4/4 R antennas were converted into SGD 4/4 RAD antennas. Here one of the antennas, one which did not have elements for control of the radiation pattern, was converted using the layout shown in Figure 1. The directional coupler in this antenna was made out of copper tubing 36 mm in diameter, and the absorbing line - out of 2-millimeter Fechral wire. The second antenna had a switch for control of the radiation pattern and was converted using the layout in Figure 4. The NO was made out of 6-millimeter copper wire, and the absorbing line - also out of 2-millimeter Fechral wire.



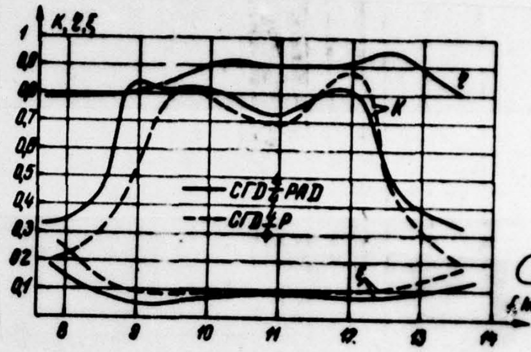


Figure 9.   Figure 10.

[СГД - SGD; РАД - RAD; Р - R]

Key: (1) MHz.

The electrical characteristics of both antennas were investigated experimentally both before the conversion of the antennas and after their conversion. Prior to conversion of the antennas their agreement with the power supply feeder line was measured, i.e., the traveling-wave ratio (twr), radiation patterns were taken under different conditions of operation, and the coefficient of protective action (kzd) was determined. After the conversion the balancing and efficiency of the antennas were measured, radiation patterns were taken under the same conditions of operation as prior to the conversion, the kzd of the antennas was determined, and the capacity of the antennas to accommodate the required power was tested. Measurements on each antenna were carried out in a range of frequencies, with a certain reserve embracing the nominal operating range of frequencies for the particular antenna. Prior to conversion of the antennas the measurements on each of the frequencies was preceded by a careful tuning of the antenna on the minimum back emission. The measurements after the conversion were made on all the frequencies without any tuning of the antennas. All the measurements were made by the same workers using the same equipment (standard set of equipment for measurements and tuning of antennas "KINA").

The measurements showed that the radiation pattern for the SGD 4/4 RAD antenna both in form and in width (on half power) were practically no different from the corresponding radiation patterns for the SGD 4/4 R antenna, tuned on the minimum back emission.

In Figures 9 and 10 the broken line indicates the results of measurement of the twr (K) and the kzd (ξ), obtained on the two antennas mentioned prior to their conversion (SGD 4/4 R), and the solid line - the twr, kzd and efficiency (η), obtained after the conversion (SGD 4/4 RAD). It is evident from these drawings that the protective action of the SGD 4/4 RAD antenna is practically no different from the protective action of the SGD 4/4 R under the condition that the latter is tuned for the best kzd on each frequency. Balancing of the SGD 4/4 RAD antenna on the whole is somewhat better than for the SGD 4/4 R. The efficiency of the SGD 4/4 RAD antenna in the greater part of the operating range of frequencies has a magnitude of 90% and higher, and only on the edge of the long-wave range it drops to 70-80%.

The check of the capacity of the SGD 4/4 RAD antenna to accommodate the required power was made on different frequencies of the range. A transmitter with a power of 100 kW in the mode of 100% modulation was hooked up to the antenna. In this case no flares, sparking or heating up were detected even in wet, rainy weather.

Thus it follows from the results of the measurements given above that the SGD 4/4 RAD antenna operates satisfactorily without any tuning in the same frequency range as the corresponding SGD 4/4 R under the condition that it was tuned on each of the frequencies.

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